

SITE: Florida Phosphate
BREAK: 9.1
OTHER: V.1

Summary and Impact of Florida Department of Health (FDOH) Historical Radiological Survey Data

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General Summary of FDOH Historical Radiological Survey Data

Background

- Radiological survey data covering planned building developments were collected by FDOH from the mid 1970's to mid-1990's.
- The survey program appears to have started as a result of EPA and FDOH studies conducted in the mid to late 1970's.
- At one point during the mid 1980's gamma surveys were required by local building ordinances prior to approval of housing developments.
- Developers typically requested surveys, FDOH provided data and recommended building design modifications if warranted.
- Most of the surveys are for undeveloped, planned residential properties and vary considerably in scope, ranging from one lot, to multi-acre subdivisions. A few commercial properties are also included in the survey files.
- Locations are unequally distributed across Polk County and there are large areas with no data.
- The survey program was discontinued approximately 10 years ago.

General Summary of FDOH Historical Radiological Survey Data (cont.)

General Historical Survey Approach

- Survey data typically consisted of multiple outdoor gamma exposure rate measurements (often this was the only type of measurement taken).
- Gamma exposure rates were typically taken with a NaI detector, calibrated to a pressurized ion chamber (PIC).
- Some surveys included radon or radon progeny measurements (indoor concentration or outdoor soil flux).
- Very few surveys included any soil samples for Ra-226.
- Documentation of results varies considerably, with some files including a summary letter from FDOH with results and recommendations, and other files containing only a property map with no survey data.

General Summary of FDOH Historical Radiological Survey Data (cont.)

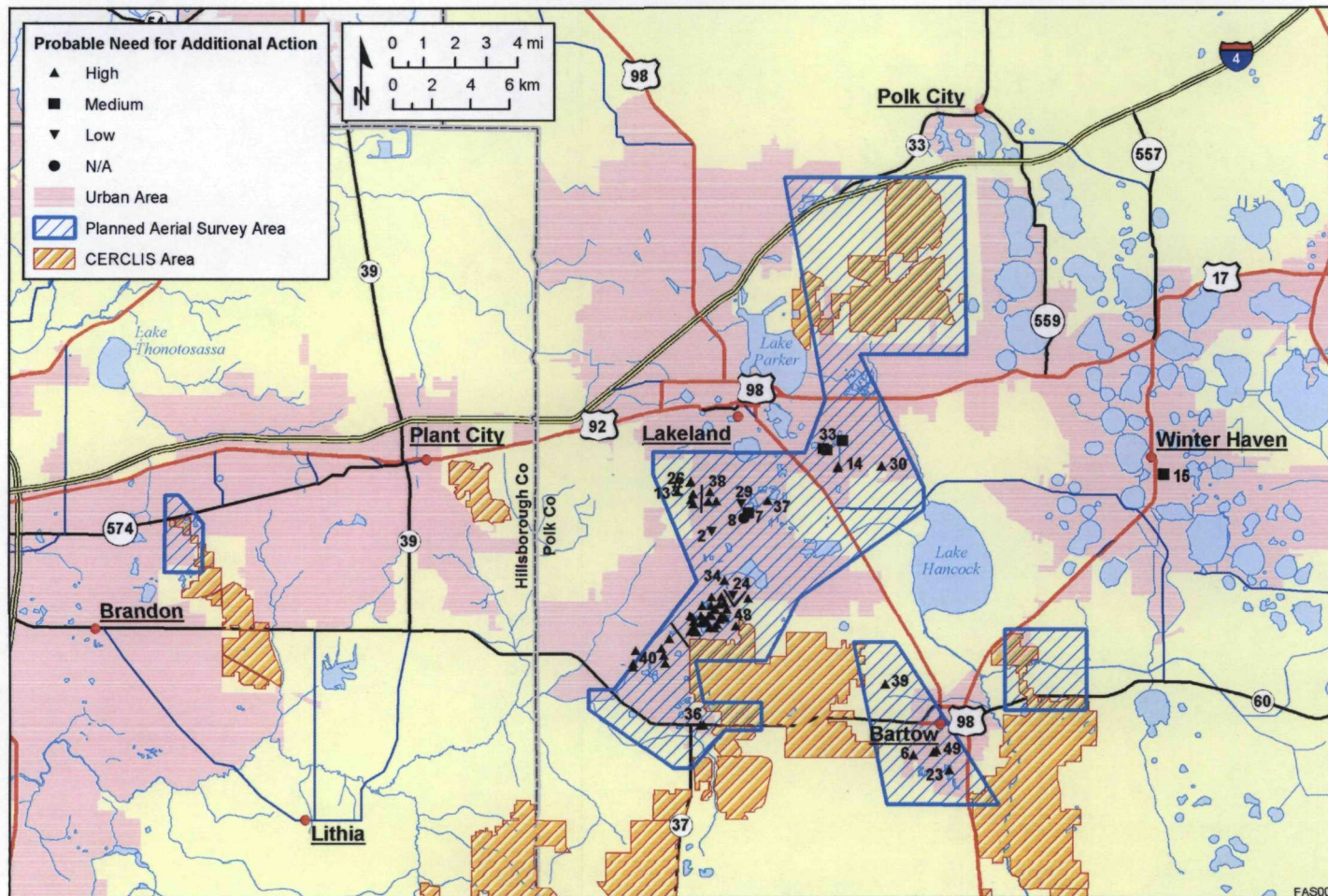
Summary of Results

- Gamma exposure rates show large variability, ranging from background (~6 $\mu\text{R/hr}$) to ~100 $\mu\text{R/hr}$.
- Many areas identified as containing phosphate clay (slimes) and sand tailings showed numerous measurements > 20 $\mu\text{R/hr}$ (typically 20 – 40 $\mu\text{R/hr}$).
- Summary table provides data on average and maximum measurements for gamma exposure rate, Rn-222, and Ra-226 soil concentrations for each subdivision or development (all types of measurements not available on all properties).
- Table also provides a qualitative indicator of the potential need for additional action (characterization or remediation) using H (high), M (medium), and L (low) probability indicators.
- Designation as H, M, or L based on likelihood of exceeding one or more of the current guidelines used to trigger remedial actions (20 $\mu\text{R/hr}$ gamma, 4 pCi/L Rn-222, 5 pCi/g Ra-226) for similar sites.

General Conclusions from the Historical Surveys Review

- Most of the historical surveys cover areas that are within the planned aerial survey coverage area.
- The historical surveys provide useful information that support the scope (areal extent) of the planned aerial survey.
- Approximately 50% of the areas surveyed were designated as H, indicating high potential for some properties within that development to exceed current cleanup guidelines.
- While many properties were covered in the historical surveys, there are large areas of potential concern that were not surveyed.
- The surveys provide evidence that a significant number of residential properties located over former mine areas have the potential to contain radioactivity (Ra-226) at levels exceeding current remedial action guidelines.
- Overall the historical survey results support the concept that additional screening or characterization surveys are warranted for residential developments built over former phosphate mines.

General Conclusions from the Historical Surveys Review – Summary Map



Impacts of Historical Data Review, and Potential Next Steps (cont.)

- Historical data show that further characterization activities are warranted, based on cleanup guidelines currently used for Ra-226 sites.
- It is assumed that if remedial actions are ultimately needed, the guidance provided in MARSSIM will impact decision making.
- A logical next step is implementation of a cost effective screening survey methodology that will allow identification of specific areas of concern, and provide for classification of areas consistent with MARSSIM guidance.
- This screening methodology should also be capable of providing information useful in designing ground-based characterization and final status surveys.
- A second logical next step is to initiate planning/discussions on potential cleanup guidelines.

Impacts of Historical Data Review, and Potential Next Steps

- Considerations important to the ultimate design of future characterization surveys:
 - What is the cleanup guideline (DCGL)?
 - What is the confidence level associated with the cleanup guideline? (e.g. 95% confidence of not calling dirty area clean)
 - What is the size of the averaging area (exposure unit) that the cleanup guideline will be applied to? (e.g. ½ acre residential parcel?)
 - What is the variability of the primary radionuclide of concern (std. dev.), and is this radionuclide likely to be localized in small areas, or spread uniformly over larger areas?
 - How will areas be classified as unimpacted, and impacted class 1, 2, and 3. (this is critical to a cost-effective final status survey plan)

Impacts of Historical Data Review, and Potential Next Steps (cont.)

- A large scale aerial survey such as the current plan is a very effective way to establish initial MARSSIM unimpacted, and impacted class 1, 2, and 3 areas.
- Such a survey can also provide initial estimates of the variability of the primary radiological constituents (this is important for later MARSSIM survey plan design).
- Because of the potential for protracted negotiations, discussions of potential applicable cleanup guidelines should begin in parallel with the aerial survey if possible.

Impacts of Historical Data Review, and Potential Next Steps (cont.)

- If needed, selected ground based surveys could begin early, but without information on critical survey design parameters, these surveys may ultimately have minimal decision value.
- The optimum approach for MARSSIM survey design would be to
 - Use the results from an aerial survey in area classification decisions and to establish initial radionuclide variability.
 - Then use the results from cleanup guideline discussions (DCGL, confidence level, averaging/exposure unit size) to finalize the approach for characterization and final status survey plans.
- Ultimately action/no-action decisions will be made based on conditions over approximately ½ acre size exposure units. To cost-effectively apply MARSSIM guidance over the entire phosphate mine area of concern requires use of an effective screening tool to get the initial classifications correct, and to avoid survey re-work.

Kerr-McGee Residential Areas Sites (West Chicago) Comparison

Background

- Kerr McGee operated a thorium extraction facility in West Chicago from 1932 to 1973. Waste tailings contained Th-232, Th-228, and Ra-228.
- Tailings from the process were stockpiled at the factory, and available to the local community for fill (sand-like material).
- Residential areas became contaminated as a result of thorium tailings placement (fill), runoff and wind erosion from piles at the factory.
- First aerial survey of the West Chicago area conducted in 1977 by EG&G. Survey identified 75 thorium waste deposits.



Kerr-McGee Residential Areas Sites (West Chicago) Comparison

Background

- Kerr- McGee conducted voluntary removals in 1984/85 using a criteria of 30 $\mu\text{R/hr}$ (based on 20 $\mu\text{R/hr}$ over background).
- Second aerial survey conducted in 1989 by EG&G for IDNS. Covered approximately 300 acres.
- Limited school and residential surveys conducted by IDNS beginning in 1989. Generally outdoor gamma measurements, some soil sampling and Rn/Tn measurements
- IDNS data showed Th-232 at schools from 3 - 35 pCi/g, and 28 – 780 pCi/g at residences. Gamma exposure rates at schools ranged from 3 – 11 $\mu\text{R/hr}$ over background, while residences ranged from 52 – 590 $\mu\text{R/hr}$ over background.



Kerr-McGee Residential Areas Sites (West Chicago) Comparison

CERCLA Characterization Approach

- In 1994 Decision Criteria document published, establishing action thresholds for Discovery, Characterization, and Verification phases of the project (based on ARARs).
- Key discovery/characterization criteria included 5 pCi/g for Ra-226 + Ra-228, 0.02 WL for Rn/Tn decay products, and “statistical exceedance of background” for indoor and outdoor gamma exposure rates.
- Outer gamma contour of 2nd aerial survey used as starting point for ground based CERCLA characterization efforts that started in 1994.
- Initial characterization actions included detailed gamma walkover measurements, mapping gamma contours, and soil sampling based on gamma results. Selected indoor Rn/Tn sampling also conducted.
- MARSSIM not used (not published until 1997) but verification process technically allowed averaging soil concentrations over 100 m² (averaging was not typically used).

Kerr-McGee Residential Areas Sites (West Chicago) Comparison

Remedial Action Approach

- Removal Program approach used to expedite action, consistent with Superfund Accelerated Cleanup Model (SACM).
- EE/CA developed using existing data, characterization activities led directly to non-time critical removal actions, with follow-up RI and no (further) action ROD.
- Initial study area (based on aerial survey) consisted of approximately 1,200 properties, later expanded to 2,170 properties.
- As of Feb. 2003, 674 contaminated properties identified, and 670 cleaned up, with removal of approximately 110,600 cy of contaminated soil.

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Table 1. Summary of Historical Florida Department of Health Radiological Survey Results for Selected Subdivisions and Property Developments

Subdivision/Development	Survey Date(s)	External Gamma (uR/hr)^a	Indoor or Outdoor Rn or Rn progeny meas.^b	Ra-226 Soil Conc. (pCi/g)	Probable Need for Additional Action (H, M, L)^c	Comment(s)
1. American Cyanamid N. E. Lakeland (1987)	5/18/87, 5/19/87	10.5 (ave) 27 (max)	NM	NM	H	212 measurements in 1987
1. American Cyanimid N. E. (1982)	5/6/82	9 (ave) 29 (max)				333 measurements in 1982. Used Ludlum 12S calibrated with PIC.
2. Harden Oak Subdivision			NM	NM	L	Map shows results from gamma survey. Text reports "readings were well below accepted limits."
3. Braden River Lakes			NM	NM	L	Map appears to show results from a gamma survey (no descriptive text or footnotes). Numbers that appear to be gamma exposure rate measurements all 5 (uR/hr?) or less.
4. Barrett, Haentjens & Company	4/19/76	16 (max indoors) 40.9 (max outdoors)	NM	NM	H	Results reported in letter that included a description of EPA's interim guidelines for phosphate lands (construction restrictions if exposure rate >10 uR/hr).
5. Berry Lake Subdivision	4/19/76	17 (ave) 29.8 (max)	NM	NM	H	Measurements taken with PIC. Transmitted in letter describing EPA interim recommendations for limiting construction on phosphate lands.

Subdivision/Development	Survey Date(s)	External Gamma (uR/hr) ^a	Indoor or Outdoor Rn or Rn progeny meas. ^b	Ra-226 Soil Conc. (pCi/g)	Probable Need for Additional Action (H, M, L) ^c	Comment(s)
6. Brittany Place Subdivision	3/6/76	19.6 (max)	NM	NM	M	Measurements taken with a calibrated NaI detector.
7. Canyon Lakes/Doremous	6/2/83	16 (max)	NM	NM	M	75 measurements taken of property. Report estimated 19% of homes built would have radon problems.
8. Correspondence					NA	Contains no radiological survey data but does include information on developers and mining history for some developed areas.
9. Cliff Manor Acres	1/30/78	2-4 (generally) Rock pile "much higher"	NM	NM		Contains one page (cover page for survey) indicating that results of gamma measurements were generally 2-4 uR/hr except for a rock and dirt pile where readings much higher (need to refer to map).
10. Citrus Groves	March 1976	General range of 6-10 uR/hr for most groves except in Bartow area.	NM	NM	H Bartow area L other areas	Several citrus groves surveyed in March 1976 with "EPA Ludlum." Gamma measurements generally low (less than 10 uR/hr) with exception of groves in the Bartow area where rates measured as high as 70 uR/hr.
11. Christina Woods, Lot 346, Phase 9.		46 (ave) 68 (max)	NM	NM	H	26 exposure rate measurements, lowest 37 uR/hr (Ludlum 12S). Letter from DoH indicates 80% probability of Rn

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						problems.
12. Blue Cove Park (Bartow)	2/7/98 (letter)	31 (ave) 60 (max)	Rn soil flux (aCi per cm ² *s) 339 (ave) 1300 (max)		H	Add notes
13. Drummond Coal Co.	7/14/80	18.1 (ave) 36 (max)	NM	NM	H	287 measurements taken and reported as uR/hr calibrated to a PIC.
14. Crystal Acres	2/25/77	No ave reported 30 (max)	NM	NM	H	No summary report of results. Maps show wide variability in exposure rates, with max of 30 uR/hr. EPA Ludlum instrument used for survey.
15. Edgewood Extension	8/29/79	No ave reported 26 (max)	NM	NM	M	Most results less than 20, ranging from 6 to ~15. Measurements taken with Ludlum 12S calibrated to a PIC.
16. Drummond Coal Co./Country Lakes Subdivision	10/9/78	Section A: 15 (ave) 35 (max) Section B: 20 (ave) 40 (max)	NM	NM	H	Section A was planned for commercial use, while Section B was planned for residential.
17. FL Phosphate Institute	2/11/82	27	5.53 pCi per m ² *s	5.6 to 16.6	H	Results shown for foundation soil after addition of clay-sand mix. Results from

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			(ave) 9.03 pCi per m ² *s (max)			four soil samples showed 5.6, 12.8, 13.1, and 16.6 pCi/g Ra-226.
18. Girls Villa	1/1/78 (letter)	NM	0.007 – 0.065 WL by TLD 0.017 – 0.098 WL by Track Etch	NM	H	Rn progeny measurements taken from 7 Girls Villa residences using two methods (TLD and Track Etch). By TLD, 4 of 7 exceeded 0.02 WL. By Track Etch, 6 of 7 exceeded 0.02 WL.
19. Branco Enterprises – Lakeland Property	1/25/78 (letter)	12.86 (ave) 20 (max)	217.56 aCi per cm ² *s (ave)	NM	M	50 acre property surveyed for gamma exposure rates (168 measurements) with Ludlum scintillation detectors. Rn flux measurements taken in 7 locations. Field notes indicate entire area filled with mining byproduct soil/clay mixture.
20. Lake Canyon	4/20/81 4/22/81 (letters)	NM	NM	NM	Unknown	Two letters in file documenting correspondence related to building requirements to provide radiation protection for the Lake Canyon development. There is no reference to survey measurements.
21. Lake Hancock Residential Community	9/3/82 (receipt)	NM	NM	NM	Unknown but	This file contains an application for a binding letter of interpretation, and

Subdivision/Development	Survey Date(s)	External Gamma (uR/hr) ^a	Indoor or Outdoor Rn or Rn progeny meas. ^b	Ra-226 Soil Conc. (pCi/g)	Probable Need for Additional Action (H, M, L) ^c	Comment(s)
	stamp)				probably H based on note.	other correspondence related to the Lake Hancock development. There is no radiological data in the file. A handwritten note on the application indicates that the area "should be gamma surveyed ASAP – it is probably hot as a pistol," but no data is available.
22. Meadow Lakes Development	9/22/80 (letter) 11/6/81 (letter on mobile home portion)	13 (ave) 48 (max) 30 (ave. on portion for mobile homes)	NM	NM	M	Meadow Lakes is a large multi-use residential development that includes single family homes multi-family townhomes and garden apartments, a park and commercial areas.
23. Mission Oaks Subdivision	5/13/76 (letter)	21.4 (ave) 38 (max)	NM	NM	H	Survey consisted of 22 gamma measurements taken mostly along public right of way of subdivision.
24. Morningview Subdivision	7/24/86 (letter) 6/24/86 (letter)	Generally background (2 nd survey) 11 (max) (1 st survey)	NM	NM	L	Two gamma surveys conducted. In first survey a couple of areas were identified with exposure rates greater than background (11 uR/hr max). After removal of one foot of soil from these areas they showed background exposure rates.
25. Mustang Village	4/27/79	34 (max)			H	All gamma exposure rates greater than

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Development						20 uR/hr, general average approximately 25 uR/hr, with a maximum of 34 uR/hr.
26. Oakbridge Development	5/27/86	15-25 over general area 50 (max)	NM	NM	H	Gamma exposure rates taken from radiation map prepared by the developer (measurements confirmed by State).
27. The Pathways Subdivision	12/21/78 (letter)	20 (ave) 50 (max)	NM	NM	H	Gamma exposure rate measurements performed on 60 acre parcel using a Ludlum 12S calibrated to a PIC in December 1978. Gamma survey performed over smaller area in September 1977.
	9/22/77 (initial survey)	generally >10 35 (max)	NM	NM		
28. Phosphate Field Maps Mined and Unmined Areas	NA	NM	NM	NM	NA	File contains field maps showing areas of phosphate mines and unmined areas.
29. Raintree Village	10/1/86	Generally background 7 (max)	NM	NM	L	Gamma survey showed generally background exposure rates (max at 7 uR/hr).
30. Saddle Creek Village	3/6/80	No ave reported 24 (min) 35 (max)	NM	NM	H	Letter reports that all gamma measurements were 24 uR/hr or higher (max 35), with strong probability that homes would have radon problems.
32. Ned Sinder Property	2/15/84 (letter)	11.3 (ave) 16 (max)	NM	NM	M	All exposure rate measurements less than 20 uR/hr, but most were approximately 2x background.

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33. Skyview Estates Development	5/11/76 (letter)	~9-10 (ave) 19 (max)	NM	NM	M	Exposure rate survey conducted due to initial mortgage insurance refusal by FHA (due to radiation concerns). Three different survey maps provided, apparently of different portions of the Skyview development. The highest reported measurement was 19 uR/hr, with a general average (all maps) of approximately 9-10 uR/hr.
34. Victoria Square Phase II	11/9/89	30 (max)	NM	NM	H	No summary report provided, but gamma exposure rate map shows four areas with ranges of 6-10 uR/hr, 15-30 uR/hr, 20-30 uR/hr, and 6-10 uR/hr.
35. Village South Project	5/14/79 (letter)	9 (ave) 12 (max) 8 (indoor)	NM	NM	M	Report notes that six lots proposed for development exceed the interim guideline of 10 uR/hr for residential dwellings.
36. West Mulberry Heights Subdivision	6/23/77	14 (min) 31.5 (ave) 60 (max)	NM	NM	H	Subdivision
37. Woodlake	9/29/80	9 (min) 13 (ave) 15 (max)	NM	NM	H	10.5 acres

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37. Woodlake		3 (min) 10 (ave) 24 (max)	NM	NM	H	122 readings
37. Woodlake		9.2 (min) 13.6 (ave) 26 (max)	NM	NM	H	26 readings
38. Imperial Southgate	4/5/76	5 (min) 15 (ave) 24 (max)	NM	NM	H	Carver property
38. Imperial Southgate	3/16/76	8 (min) 13 (ave) 19 (max)	NM	NM	M	Scott Kelly property
39. Highland Tracts	12/19/77	6 (min) 17 (ave) 35 (max)	NM	NM	H	100 acres
40. Imperial Lakes	5/19/76	1 (min) (no ave) 50 (max)	NM	NM	H	No average exposure rate provided. 234 locations.
40. Imperial Lakes	5/6/76	1 (min) (no ave) 50 (max)	NM	NM	H	1,400 acres total, 517 acres singles, 304.5 acres multi-units, 470 acres open space, 69 acres commercial, 39 acres community services.
41. Miscellaneous Gamma Surveys	7/3/79	4 (ave indoor) 5.5 (ave	NM	NM	L	3215 Wren Lane Mulberry, FL

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		outdoor)				
	11/21/85	4-5 (ave indoor)	NM	NM	L	7008 Willow Run Loop
	1/9/86	[<i>check hard copy – electronic not legible</i>]				Lot 10 of The Pinnacle subdivision
	7/31/79	2 (min) (no ave) 3 (max)	NM	NM	L	3215 Wren Lane Mulberry, FL
	7/31/79	2 (min) 3 (max)	NM	NM	L	4915 E. White Oak Dr. Lakeland, FL
	4/26/79	23 (min) 26 (ave) 35+ (max)	NM	NM	H	76 Woodside Dr. Lakeland, FL (Lot 203, Phase 6, Christina) ("35+" from survey diagram)
	4/18/85	Indoor 8 (min) 11 (max) Outdoor 12 (min) 13 (max)	NM			77 Woodside Dr. Lakeland, FL Measurements from Ludlum #7152 reported with conversion table to PIC. Max indoor and outdoor measurements of 11 and 13 respectively correspond to PIC readings of 10 and 11 respectively.

Subdivision/Development	Survey Date(s)	External Gamma (uR/hr) ^a	Indoor or Outdoor Rn or Rn progeny meas. ^b	Ra-226 Soil Conc. (pCi/g)	Probable Need for Additional Action (H, M, L) ^c	Comment(s)
	5/30/79	5 (min) (no ave) 7 (max)	NM	NM	L	5104 Woodgreen Lane Lakeland, FL
	3/31/79	2 (min) 3 (max)	NM	NM	L	4915 East White Oak Drive Lakeland, FL
42. Miscellaneous Gamma Surveys	6/19/79	3 (min) (no ave) 4 (max)	5-6	NM	L	6209 Sweetwater Drive Lakeland, FL
	7/31/84	5 (ave) 6 (max)	5	NM	L	958 Sunshine Way Winter Haven, FL
	6/18/85	4 (min) 7.9 (ave) 12 (max)	9.8	NM	M	4157 Stonelindge Lakeland, FL
	12/23/77	8 (min) 10 (max)	31 aCi per cm ² *s	NM	L	Lot 26 Dorman Acres Lakeland, FL
	2/4/86	7 (min) 9 (ave) 12 (max)	NM	NM	L	1217 Shepard Road Lakeland, FL
	4/26/96	15 (min) (no ave) 20 (max)	12 - 15	NM	H	835 Scott Lake Village Lakeland, FL
	6/7/79	10 (ave)	NM	NM	L	Lot 74 Secret Cove subdivision
	2/4/86	10 (min) (no ave)	8-10	NM	M	65 Shadow Lane Lakeland, FL

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		15 (max)				
	6/18/79	8 (ave) 11 (max)	7.5	NM	L	117 Shadow Lane Lakeland, FL
	4/25/80	7 (max)	NM	NM	L	1803 Tristram Lakeland, FL
43. Miscellaneous Gamma Surveys						
44. Miscellaneous Gamma Surveys						
45. Miscellaneous Gamma Surveys						
46. Miscellaneous Gamma Surveys						
47. Miscellaneous Gamma Surveys						
48. Christina Area	8/25/77	8 (min) 26 (ave) 40 (max)	440-31,700 aCi/per cm2*s	NM	H	Stephens property (no relation to George Stephens)

Subdivision/Development	Survey Date(s)	External Gamma (uR/hr) ^a	Indoor or Outdoor Rn or Rn progeny meas. ^b	Ra-226 Soil Conc. (pCi/g)	Probable Need for Additional Action (H, M, L) ^c	Comment(s)
49. Floral Park	11/25/98	Indoor 12 (min) 26 (ave) 32 (max) Outdoor 13 (min) 19 (ave) 33 (max)	Indoor Rn = 4.6 pCi/L	NM	H	Garboury property
50. Brittany Place	3/85	14 (min) 16 (ave) 18 (max)	5.5 aCi per cm2*s	14.8 (max)	H	Lot 22
	3/85	13.9 (min) 16.6 (ave) 23.8 (max)	4.5	14.8 (max)	H	Lot 23
	3/85	12.3 (min) 15.3 (ave) 18 (max)	2.5	5 (max)	M	Lot 24
	10/19/84	9 (min) 12.9 (ave) 23.6 (max)	NM	NM	H	Parrish Road
	9/12/84	13.2 (min) 14.7 (ave) 17.1 (max)	NM	NM	M	Clower Road
	9/25/84	10.9 (min)	NM	NM	H	Clower Road

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		15.6 (ave) 23.8 (max)				
	10/29/84	14 (min) 16 (ave) 18 (max)	NM	NM	M	Clower Road
51. Floral Park	7/22/97	Indoor 24 (min) 26 (ave) 28 (max) Outdoor 12 (min) 16 (ave) 20 (max)	24/26/28 indoor exposure, Rn=0.5	NM	H	Davis property
52. Bluffs of Christina Condominiums (FDOH surveys)	5/11/98	Indoor 7 (min) 13 (max) Outdoor 10 (min) 29 (max)	Indoor Rn results from four homes: 11.2, 10.2, 13.8, and 28.7 pCi/L	Surface (0-6") 16 pCi/g Subsurf. (6-10") 18.2 pCi/g	H	Numerous gamma exposure measurements made in and outside of residences at Christina Bluffs. Radon tests included for four homes, and surface and subsurface soil samples taken from one location. Results summarized from FDOH report.

Subdivision/Development	Survey Date(s)	External Gamma (uR/hr) ^a	Indoor or Outdoor Rn or Rn progeny meas. ^b	Ra-226 Soil Conc. (pCi/g)	Probable Need for Additional Action (H, M, L) ^c	Comment(s)
52. Bluffs of Christina Condominiums (consultant surveys)	May 1998	Indoor ~15 (ave) 35 (max) Outdoor ~35-40 (ave) 70 (max)	Reported FDOH indoor Rn results shown above.	Three samples taken: 50.8, 16.2, and 11.5 pCi/g Ra-226	H	Radiation Protection Services preliminary survey report. Included exposure rate measurements in eight homes and the clubhouse, and soil sampling
53. Christina Woods	8/4/85	15 (min) 24 (ave) 30 (max)	NM	NM	H	Lot 395
	4/30/85	14 (ave)	NM	NM	M	Lot 18 Pineberry Court
	4/25/83	15 (min) 27 (ave) 31 (max)	NM	NM	H	Sand Pit
	1/9/86	4 (ave)	NM	NM	L	Lot 10 Pinnacle
	7/13/97	5 (ave)	NM	NM	L	1653 Lagoon Place
	7/13/97	6 (ave)	NM	NM	L	1027 Pheasant Drive
	7/21/81	7 (min) 8.8 (ave) 12 (max)	NM	NM	L	1211 Rolling Woods Lane
	7/9/79	9 (min) 10.6 (ave) 13 (max)	NM	NM	L	1310 Rolling Woods Land
	1/23/85	8 (min)	NM	NM	L	3029 Pineway

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		9 (max)				
	7/22/85	8 (min) 8.7 (ave) 9 (max)	NM	NM	L	1315 Rolling Woods Lane
	3/6/79	7 (min) 13.6 (ave) 17.5 (max)	NM	NM	M	1330 Rolling Woods Lane
	8/2/85	4 (min) 7 (max)	NM	NM	L	Lot 48 Royal Crest
	6/22/77	3 (min) 8 (max)	NM	NM	L	Gilly Property

^a External gamma exposure rate measurements are outdoor measurements unless noted. Typically these measurements were taken with a Ludlum NaI detector/ratemeter calibrated to a pressurized ion chamber (PIC). However not all surveys stated that the measurements were based on calibration to a PIC. Typically the average and maximum values only are shown. In some cases if the minimum measured exposure rate was greater than background (6 uR/hr) then a separate value is shown for the minimum.

^b Indoor Rn measurements were reported in pCi/L. In some cases Rn flux (soil gas) measurements were taken and reported in units of aCi per cm²*s (or other units). These are noted in the comment column.

^c Qualitative indicator of need for additional follow-up action (characterization or remediation) using high (H), medium (M), or low (L) qualifiers based on historical data showing one or more measurements that exceed the following generic guidelines: external gamma exposure rate greater than 20 uR/hr (indoor or outdoor); Ra-226 soil concentration greater than 5 pCi/g; indoor radon (Rn-222) greater than 4 pCi/L or radon progeny greater than 0.02 WL; and radon soil gas (flux) greater than _____.

NA – Not applicable.

NM - No measurement reported.

Comparison of Radiation Dose & Risk

The following table compares radiation dose to EPA's lifetime cancer incidence risk, for various radiation doses related to natural radiation doses and to the Stauffer-Chemical offsite issue. Unless otherwise noted, the risk are calculated using Superfund defaults for 30-year lifetime, 350 days/yr, and are *incremental* of natural background radiation.

Items	Dose [mrem/yr]	Approx. Risk	Reference
Prelim. Remed. Goals	0.05	1E-6	RAGS
Cosmic dose from airplane flight from NY to LA	2.5 per flight	5E-5	
Upper end of CERCLA risk range	15	3E-4	RAGS OSWER Dir. 8/97
NRC's Cleanup Criteria	25	5E-4	10 CFR 20
Approx. Bkgd dose from cosmic radiation in U.S.	27		gamma radiation
Approx. Bkgd dose from terrestrial radiation in U.S.	28		mostly uranium, thorium, radium, and decay products
Approx. Bkgd dose from internal radiation from your body	39		mostly K-40
Exposure limit from all radiation. Sources to public: used by DOE, NRC, ATSDR, states	100	2E-3	ICRP, NCRP, & Draft EPA Fed. Guide to General Public 12/93
Avg. Occupational dose in U.S.	110	2E-3	from 1980
Indoor gamma exposure from radium contamination 20 uR/hr [for 18 hrs/d]	131	>3E-3	40 CFR 192, ARAR, used at other CERCLA Ra cleanups
ATSDR used for remedy decisions	200	4E-3	other Radium sites by ATSDR
Hartnett house	233	>4E-3	above FL bkgd
Typical FL bkgd dose	250	5E-3	assumes 6uR/hr + radon avg. dose
Avg. Natural background dose to public in U.S.	300	6E-3	30-cosmic, 40 -internal, 30-ground, 200-Rn
Infrequent exposure & Decision to relocate under EPA's Emergency Guide	500	1E-2	NCRP, EPA's PAGs, NRC
Annual limit for occupational exposure	5000	1E-1	OSHA, EPA, NRC, DOE
Acute radiation exposure, not chronic, 50% deaths in 30days	500,000 mrem [one time exposure]	-	

Comparison of Radiation Dose & Risk

The following table compares radiation dose to EPA's lifetime cancer incidence risk, for various radiation doses related to natural radiation doses. Unless otherwise noted, the risk are calculated using Superfund defaults for 30-year lifetime, 350 days/yr, and are *incremental* of natural background radiation.

Items	Dose [mrem/yr]	Approx. Risk	Reference
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NRC's Cleanup Criteria	25	5E-4	10 CFR 20
Approx. Bkgd dose from cosmic radiation in U.S.	~27		gamma radiation
Approx. Bkgd dose from terrestrial radiation in U.S.	+ ~28		~uranium, thorium, radium, and decay products
Approx. Bkgd dose from internal radiation from your body	+ ~39		mostly K-40
Exposure limit from all radiation. Sources to public: used by DOE, NRC, ATSDR, states	= ~100	2E-3	ICRP, NCRP, & Draft EPA Fed. Guide to General Public 12/93
Avg. Occupational dose in U.S.	110	2E-3	from 1980
Typical FL bkgd dose	250	5E-3	assumes 6uR/hr + radon avg. dose
Avg. Natural background dose to public in U.S.	~300	6E-3	30-cosmic, 40 -internal, 30-ground, 200-Rn
EPA's Emergency Guide & Remedial Action recommend for NORM	500	1E-2	NCRP, EPA's PAGs, NRC & NCRP116
Annual limit for occupational exposure	5000	1E-1	OSHA, EPA, NRC, DOE
Acute radiation exposure, not chronic, blood effects	10,000 mrem [one time exposure]	-	